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VIII. REACTION-TIMES.

By CHARLES S. MYERS.

Three varieties of reaction-time were investigated in Murray Island; for brevity's sake they will be termed 'auditory,' 'visual,' and 'choice-visual' reaction-times, and the men examined will be termed the 'reagents.' The auditory and the visual were so-called simple reaction-times, measuring the rapidity with which the reagent responded to one given noise or to one given visual stimulus. The choice-visual were compound reaction-times, where one or other of two known colour-stimuli was presented and an appropriate movement had to be made according to the colour which appeared. Fifty-three Murray Islanders were examined[1]. The same set of apparatus was afterwards used in Sarawak and still later in England, in each case on twenty-six individuals. The reaction-times of five members of the expedition were determined in Murray Island and of two English-men in Sarawak.

Apparatus.

The noise-stimulus of the auditory reactions was produced by the impact of a steel hammer against a steel foot, the former being drawn to the latter against the resistance of a spiral spring by means of an electro-magnet and thereby completing a second electric circuit, which was broken when the reagent lifted his finger from a Morse key. In order that it might sound with as nearly uniform intensity as possible throughout the experiments, the hammer was placed at a constant distance, above and behind the reagent, and the current to the electro-magnet was supplied from a minimal number of dry cells. The varying strength of the spiral spring, however, made it impossible to secure really absolute uniformity in the force of the impact.

The apparatus, which released the stimulus for the visual and choice-visual reactions, consisted of a large vertical screen, placed in the open air at a distance of about 35 metres from the subject and provided with a rectangular window, 20×5 centimetres. By electro-magnetic means a black board carrying a card, which was white in the case of the simple reaction, was held up from behind the top of the screen. In this position the white surface was just hidden from view and the window appeared to the reagent as black as the rest of the screen. When the board was released, it fell through a certain distance, so that the window was now occupied by a white surface. The reagent lifted his finger from a Morse key as soon as the white card became visible. For the choice-visual reactions, the same falling board was used, now carrying a card

[1] This number includes the two women and three girls, whose reaction-times are given in Table XXXIV, but who are nowhere further considered in this article.

which was covered on one surface with blue, and on the other with red paper. A second Morse key was introduced, working in a circuit alternative to that of the first. One key was depressed by a finger of the reagent's right hand, the other by a finger of his left. He was told to raise his right hand if red appeared in the window and to raise his left hand if blue appeared there. The window was temporarily covered by a piece of cloth, while the board was being replaced in a position ready to fall.

It was considered so improbable that the reaction-times of a primitive people like the Murray Islanders could be profitably investigated, that only the simplest and least costly registering apparatus was included in the psychological outfit of the expedition. Thus, in default of a chronoscope, the reaction-times were recorded by means of a simple time-marker and a Deprez' signal upon the smoked surface of a hand-rotated drum, the frame of which carried a knock-down key. The Deprez' signal was connected with an electrically driven tuning-fork which vibrated fifty times a second. During rotation of the drum the knock-down key led to the production of the appropriate sensory stimulus by breaking a pre-existing current. For the auditory reactions a simple apparatus, devised for us by Captain E. T. Dixon, was introduced, whereby the breaking of the current by the knock-down key served to complete another current which acted on the hammer. The time-marker registered (1) the impact of the hammer, or the release of the board from behind the screen, and (2) the reaction of the subject. In the case of the screen the moment when the board was released did not coincide with the moment when the white card appeared in the window. I found that the average time (latent period) taken for the board to fall completely, so that the whole of the window was occupied by the white card, was 108^{σ}; that the average time (nine trials) for the board to fall, so that half the area of the window was occupied by the white card, was 85^{σ} (m.v. = 3); and that for the lower edge of the card just to appear at the top of the window an average time (eight trials) of 41^{σ} (m.v. = 4) was necessary[1]. I have therefore always deducted 60^{σ} from the actual results, assuming that the card was visible to the reagent before, having completed its fall, it had occupied the whole of the window.

Experimental Methods.

The room in which the Murray Island reagent sat was separated by a small room from that containing the recording apparatus. In practically every set of auditory reactions an observer stood beside him, in order to watch if he were reacting properly and if he gave premature or erroneous reactions. In the visual and choice-reactions this observer stood in the open air behind the screen, in order to replace the card after every fall. From this position he could notice how the individual reacted in the simple visual reactions, and whether or not he reacted appropriately in the choice-visual reactions[2]. In the latter experiments, one had of course to be on one's guard that the subject was not trying to make out if the card was being reversed during replacement. Three individuals, whose behaviour in this respect was suspicious, were re-examined under conditions which made it absolutely impossible for

[1] All measurements in this section are expressed in σ, i.e., thousandths of a second.

[2] I am much indebted to Dr Rivers for his unfailing help in this direction.

them to detect the movements of the assistant at the screen, but the results of the second series were in every way consistent with their previous reactions. There can, indeed, be no doubt that in these, as in our other experiments, the islanders, as a rule, made no attempt to go beyond what they were told to do. They settled down at once to record their reaction-times in a straightforward manner.

I found no difficulty in explaining to the Murray Islanders the general bearing of reaction-time experiments. I pointed out that individuals must vary in the time taken to shoot at a suddenly appearing object after they had first observed it, and they seemed clearly to understand that I was somehow able to find out whether they were likely to be good or bad marksmen by studying the rapidity of their reactions. At the close of the experiment they would view the tracings with evident interest, and ask whether they had been quick or slow, occasionally enquiring how they compared with some other Murray Islander. There is, therefore, every reason to believe that the reagents, as a whole, were doing their best to produce their quickest reactions. Perhaps the least interest was shown by those who through slightly defective vision or hearing imagined that they would prove bad subjects for the experiment. But their results were apparently as reliable as those of the others.

Each individual was allowed to react in the way which seemed best to him. There was no attempt to turn his attention in the direction either of the stimulus or of the movement. The only care taken was that he did not press so heavily on the Morse key as thereby to retard his reaction-time materially. The key was placed on a low table before which the reagent sat. One finger, usually the index finger of the right hand, was placed comfortably on the key. A warning "Now!" from the room containing the registering apparatus prepared the subject for the reaction. After an interval, varying as nearly as possible between one and two seconds, the drum was rotated and the reaction-time recorded. The observer, who watched the movements of the reagent, was careful to notify anything abnormal in the reaction: this he communicated to me, who had charge of the registering apparatus. After every choice-reaction the observer, who now stood beside the screen, cried out, "right, blue," "wrong, red," thus naming the colour exposed and informing me whether the subject had reacted with the appropriate hand.

Every individual was allowed a few preliminary trial-reactions, the number of which depended on the speed with which he settled down to his task of giving a succession of seemingly reliable reactions. On an average, perhaps, six such reactions were given in each series. Even in the difficult choice-visual series they rarely, if ever, exceeded ten. All subsequent reactions, premature, normal and prolonged, were recorded, so far as was possible. Unfortunately, however, with such imperfect, clumsy apparatus as I had to work with, occasional breaks in the records were inevitable. Sometimes the markers had not been accurately brought to bear on the travelling surface, sometimes the tuning-fork was not vibrating as it should, or owing to inadequate magnetization the screen fell before the warning had been given. These and other mishaps made it impossible always to secure a really accurate, uninterrupted record of reactions. But throughout, the reactions that were not registered are so few that the omission can make no appreciable difference in the results.

The rapidity with which the reactions followed on one another at any one sitting varied with the kind of reaction. The auditory reactions could be repeated most quickly, about eight per minute. The visual reactions recurred rather more slowly, as the fallen card had each time to be carefully replaced. The interval between successive choice-visual reactions was so long (averaging nearly half a minute) that possibly the reagent formed some opinion meanwhile as to which of the two colours would next appear in the window.

These and other defects, however, operated to an equal extent in Sarawak and in England among the individuals there examined, with whom the Murray Islanders are to be compared.

Each sitting usually lasted between twenty and thirty minutes. Two kinds of reaction (the auditory and visual or the visual and choice-visual) were generally tried at one sitting. An interval of a few minutes was allowed, during which the necessary alterations in apparatus were made, and the reagent could rest himself before beginning a new kind of reaction. Most subjects made their first start with the auditory reactions. In the case of a few islanders experiments were limited to this mode of reaction. But in by far the majority the visual reaction-time was also determined, and this series of experiments followed on the auditory time-experiments. Some days or weeks later a second sitting was obtained, at which the choice-visual method was usually employed, followed often by a few simple visual reaction-times. Two or three series of auditory or visual reaction-times were obtained on different days from a few islanders. But only the first series of reaction-times are taken into account in the following pages, save where the influence of practice and fatigue is being considered.

Arrangement of the Data.

The task of presenting the experimental results of reaction-times concisely and at the same time satisfactorily is indeed a difficult one. Nearly every worker at the subject has elaborated his own method, so that his data, while comparable *inter se*, are incomparable with those obtained by other workers.

The chief difficulty lies in the fact that, when observations are made on imperfectly trained individuals, they are sure to contain a few values which in one or other direction differ very widely from the mean. Such values, if very low, may be premature reactions, or they may be false reactions where the individual reacts to a stimulus which he has mistaken for the proper stimulus. The very high values are usually due to lapses of attention; but, in my Torres Straits experiments, at least, they arose occasionally from undetected premature reactions, after which the individual had so little time to readjust his finger before the proper stimulus was presented that his reaction to the latter was delayed.

It is needless to point out that these well-known aberrant values affect the mean reaction-time very considerably. We may escape easily enough from the difficulty of dealing with them, if we accept the view that sporadic experiments, made upon this or that person, who is devoid of experimental training and unlearned in methodical introspection, are valueless. But one of the aims of this section is to

prove that such experiments are very far from being unprofitable. We note that some workers[1], by bringing the reagent's introspective observations into relation with his time-records, have attempted to solve the difficulty in this way. But introspection is all but impossible in the case of a primitive people. Others, after having taken the average, have excluded that value which deviated most from that average and, after taking a fresh average, have in similar fashion ruled out the next most aberrant value, the process being repeated several times[2]. Most workers, however, pass over their method of treating the aberrant reactions of the insufficiently practised in silence.

There are two reasons, at least, which make it difficult or inadvisable to separate aberrant reactions from the rest. In the first place, it is impossible to fix any but the widest limits, applicable to all individuals, of which it can be said that only those reactions are to be accepted as true which fall within them. Secondly, the elimination of aberrant reactions is (or, at least, always has been) tantamount to their neglect. Now these fluctuations are one of the most interesting features of reaction-times. *À priori*, it is highly improbable that the average minimal (*quasi*-automatic) reaction-time, if only the reagent be adequately practised, differs widely in different communities. On the other hand, in a comparative psychological study of peoples or of individuals, the extent and meaning of the variations from the average are obviously well worth an attempted investigation.

Accordingly in Table XXXIV. *no recorded reaction-time has been omitted*, the aberrant reactions being invariably included with the rest. But some idea of their frequency may be gained by an inspection of the columns headed *Abn.* The unduly shortened reactions are denoted by the letter α, the unduly prolonged by β; the figure following α or β gives the number of such reactions. I have already alluded to the impossibility of having fixed values for α and β, unless the value of α be so low, and that of β be so high, that they are likely to suit the needs of practically every individual. I have therefore arbitrarily fixed the limits of α and β respectively at 70^{σ} and 300^{σ} for auditory, at 120^{σ} and 350^{σ} for visual, and at 250^{σ} and 850^{σ} for choice-visual reactions. In many individuals, of course, an auditory reaction-time of 90^{σ} may really be premature, or a visual reaction-time of 280^{σ} may be unduly prolonged. Nevertheless the number of α and β reactions will afford a fair guide to the frequency of aberrant reactions.

In the same tables two sets of figures will be found for every reaction. In the auditory and visual reactions the first set contains the *average* of the first ten reaction-times, the second set contains the *median* of all the reaction-times obtained at one sitting[3]. The figures in the column next to that marked *median* indicate the *number* of such reactions from which the median was obtained.

It seemed worth while to record the average of the first ten observations because several previous workers have adopted this procedure. Nevertheless, it must be remembered that such an average reaction-time is in reality a very poor indication of the true

[1] Cf. S. Exner, *Arch. f. d. ges. Physiol.* 1873, Bd. VII. S. 644 ff.; G. Martius, *Phil. Stud.*, Leipzig, 1891, Bd. VI. S. 199; G. Dwelshauvers, *ibid.* S. 222.

[2] J. McK. Cattell, *Phil. Stud.* 1886, Bd. III. S. 317, 318; L. Witmer (*Proc. Amer. Psychol. Ass.*, 1893, p. 7) adopts a similar plan.

[3] In a few cases, where less than ten reactions were obtained at one sitting, the average of the total is substituted for that of the first ten.

Table XXXIV.

Name	Age	Auditory									Visual									Choice-visual								
		Series	Av. of 10	m. v.	v. c.	Abn.	Median	of	m. v. q.	Abn.	Series	Av. of 10	m. v.	v. c.	Abn.	Median	of	m. v. q.	Abn.	Series	Av. of 10	m. v.	v. c.	Abn.	Median	of	Abn.
MEN																											
Mamus	60	1, i.	147·0	7·0	5	...	145·0	17	7·5	...	1, ii.	271·0	26·4	10	β_1	255·0	17	35·0	β_1	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	2, ii.	280·5	77·3	28	β_1	235·0	9	51·25	β_1	2, i.	466·5	67·8	15	...	455·0	31	...
Azò	55–60	1, i.	196·0	28·0	14	...	200·0	15	17·5	...	1, ii.	204·0	28·8	14	...	195·0	16	27·5	β_1	...	...	...	...	...	...	...	...
Dauai	„	1	316·0	39·2	12	β	300·0	16	43·75	β_9	....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lui	„	1	467·0	97·6	21	β_9	470·0	21	93·75	β_{18}	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ulai	„	1, i.	140·5	28·3	20	α_1	152·5	15	13·75	α_1	1, ii.	290·5	44·6	15	β_1	260·0	15	32·5	β_1	...	...	...	...	...	...	...	...
„	„	2, ii.	162·5	16·0	10	...	160·0	11	12·5	...	2, i.	257·5	18·0	7	...	252·5	18	20·0	β_1	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	3, ii.	280·0	25·0	9	...	275·0	4	25·0	...	3, i.	491·0	79·2	16	...	490·0	37	β_1
Wanu	„	1	182·0	29·2	16	...	160·0	30	15·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	„	2, ii.	143·0	17·6	12	...	135·0	5	20·0	...	2, i.	200·0	14·0	7	...	200·0	16	16·75	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	3, ii.	287·5	37·6	13	β_1	280·0	6	32·5	β_1	3, i.	565·0	127·0	22	β_1	610·0	15	$\alpha_1\beta_2$
Alo	50	1	141·0	19·2	14	...	142·5	32	17·75	α_1	2, ii.	315·0	37·8	12	β_1	300·0	9	12·5	β_1	2, i.	572·2	57·5	10	...	550·0	23	β_3
Canoe	45–50	1	130·5	24·5	19	...	130·0	10	22·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	„	2, ii.	100·5	54·3	54	α_3	115·0	12	35·5	α_3	2, i.	161·5	88·4	55	α_2	185·0	25	17·5	α_2	3	?	?	?	?	?	?	?
Jimmy Dei	„	1	129·0	22·0	18	...	132·5	30	20·0	...	2	216·0	11·0	5	...	220·0	14	15·0	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	3, ii.	310·0	18·75	6	...	312·0	8	16·25	...	3, i.	548·0	118·0	21	β_1	545·0	24	β_2
Sisa	45	1, ii.	82·5	73·6	90	α_5	115·0	16	52·5	α_7	1, i.	562·0	135·2	24	β_8	585·0	18	190·0	$\alpha_1\beta_{10}$	...	...	...	...	...	...	...	...
Wasalgi	„	2	107·5	24·5	23	α_1	120·0	27	12·5	α_3	1, i.	197·5	15·5	8	...	195·0	21	16·25	...	...	...	...	...	...	...	...	...
Baton	40–45	1	146·0	22·0	15	...	135·0	27	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Capsize	„	1, i.	245·5	31·6	13	β_1	250·0	14	27·5	β_2	1, ii.	211·0	35·7	17	...	195·0	9	38·75	...	...	...	...	...	...	...	...	...
„	„	2, i.	183·0	81·6	45	$\alpha_2\beta_2$	225·0	19	52·5	$\alpha_2\beta_4$	2, ii.	377·0	73·6	20	β_3	380·0	5	91·25	β_3	3	620·0	60·0	10	...	630·0	26	...
Pasi	„	1	109·5	12·5	11	...	105·0	23	12·5	α_1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	„	2, ii.	108·5	12·8	12	...	110·0	10	7·5	...	2, i.	214·5	21·4	10	...	217·0	16	18·75	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	3, ii.	233·5	26·2	11	...	220·0	11	17·5	...	3, i.	416·3	34·7	8	...	432·5	24	...
Magi	40	1, ii.	113·5	45·4	40	α_2	115·0	16	33·75	α_4	1, i.	224·0	13·2	6	...	227·5	10	17·5	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	2, ii.	284·0	45·2	16	β_1	287·5	10	50·0	β_1	2, i.	431·5	47·8	11	...	422·5	24	...
Maboali	„	1	105·0	28·0	27	α_1	97·5	30	17·5	α_5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Papi	„	1	311·5	66·1	21	β_5	305 0	16	30·0	β_{11}	2, ii.	345·7	33·5	10	...	350·0	7	35·5	...	2, i.	432·5	46·5	11	...	430·0	19	...
Debe Wali	35–40	1	98·5	37·8	38	α_3	145·0	36	33·75	α_4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Kadub	„	1, ii.	121·5	20·5	17	α_1	127·5	14	20·0	α_1	1, i.	288·0	51·6	18	β_1	260·0	15	40·0	β_1	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	2, ii.	255·0	22·0	9	...	260·0	8	28·75	...	2, i.	553·5	40·5	7	...	560·0	18	β_1
Barsa	35	1, i.	123·5	31·5	26	α_1	120·0	13	25·0	α_1	1, ii.	234·5	18·5	8	...	240·0	15	17·5	...	...	...	...	...	...	...	...	...
Billy Kuris	„	1	131·0	21·8	17	α_1	137·5	14	15·0	α_1	2, ii.	314·3	68·0	22	β_3	320·0	7	62·5	β_3	2, i.	493·0	[9]58·7	12	...	450·0	21	...
Charlie Boro	„	1, ii.	116·0	11·2	10	...	115·0	11	7·5	...	1, i.	217·5	51·0	23	$\alpha_1\beta_1$	205·0	13	32·5	$\alpha_1\beta_2$	2	513·5	74·5	15	...	500·0	31	...

Groggy	35	1	140·5	8·7	6	...	135·0	13	11·25	...	2, ii.	267·0	29·8	11	...	247·0	10	17·5	β_1	2, i.	564·0	47·0	8	...	565·0	20	β_1
Babelu	30–35	1	139·5	12·6	9	...	145·0	18	7·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mabo	„	1	104·5	4·5	4	...	105·0	25	10·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dick Tui	30	1, i.	136·5	14·5	11	...	140·0	19	15·0	...	1, ii.	250·5	17·6	7	...	250·0	12	15·0	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	2, ii.	276·1	31·0	11	...	290·0	9	32·5	...	2, i.	398·0	58·0	15	...	395·0	18	...
Beni	25–30	1	167·5	32·0	19	...	155·0	15	22·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Jimmy Wailu	25	...	...	...	...	...	...	...	...	...	1	240·5	26·6	11	...	255·0	28	22·5	β_1	...	...	...	...	...	...	...	...
Loko	„	1	155·0	26·0	17	...	150·0	15	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Poï	„	1, ii.	86·5	28·9	33	a_2	100·0	11	25·0	a_2	1, i.	225·0	24·0	11	...	220·0	13	32·5	...	...	...	...	...	...	...	...	...
„	„	2	166·5	7·8	5	...	165·0	16	7·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dubwai	20–25	1, ii.	130 0	38·0	30	a_1	125·0	12	26·25	a_2	1, i.	282·5	25·0	9	...	300·0	17	23·75	...	...	...	...	...	...	...	...	...
Tapau	21	1	166·0	25·4	15	...	157·5	14	20·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Deboro	19	1	188·5	12·5	7	...	187·5	10	12·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dick (Dauai)	18	1	192·0	11·4	6	...	190·0	11	12·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	„	2, ii.	122·0	15·6	13	...	125·0	5	18·75	...	2, i.	224·0	12·8	6	...	220·0	24	12·5	...	...	...	...	...	...	...	...	...
Madsa	„	1, ii.	132·0	13·4	10	...	125·0	11	15·0	...	1, i.	207·0	17·4	8	...	205·0	20	12·5	β_1	...	...	...	...	...	...	...	...
Berò	17	1	121·0	7·2	6	...	120·0	32	7·5	...	...	...	...	...	...	...	...	...	...	2	500·5	81·7	16	...	485·0	14	...
„	„	...	...	...	...	...	...	...	...	...	3, i.	217·0	18·4	8	...	220·0	19	20·0	...	3, ii.	409·0	32·6	8	...	397·5	12	...
Kaniu	„	1	107·5	24·5	23	...	100·0	26	12·5	a_3	...	...	...	...	...	...	...	...	...	2	?	?	?	?	?	?	?
WOMEN																											
Biged	40–45	1	150·5	97·1	65	$a_3\beta_1$	177·5	18	105·0	$a_5\beta_2$	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Banuga	19	1	268·0	30·0	11	β_1	260·0	16	26·25	β_2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
BOYS																											
Apori	14	1, i.	147·5	19·0	13	...	140·0	12	17·5	...	1, ii.	279·5	18·9	7	...	270·0	11	10·0	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	2, ii.	328·0	20·0	6	β_1	325·0	10	10·0	β_2	2, i.	514·5	73·4	14	...	550·0	23	β_1
James	13	1, ii.	117·0	4·7	4	...	120·0	5	6·25	...	1, i.	228·0	18·6	8	...	240·0	15	20·0	...	...	...	...	...	...	...	...	...
„	„	2, ii.	122·1	3·4	3	...	120·0	7	2·5	...	2, i.	244·5	26·4	11	...	232·5	14	17·5	...	...	...	...	...	...	...	...	...
„	„	...	...	...	...	...	...	...	...	...	3, ii.	244·5	23·3	10	...	240·0	12	22·5	...	3, i.	548·0	61·6	11	...	575·0	22	β_1
Jimmy Rice, jun.	$12\frac{1}{2}$	1	140·0	16·0	11	...	140·0	18	10·0	...	2, ii.	288·5	48·8	17	β_1	260·0	12	12·5	β_1	2, i.	535·5	[9]70·0	13	...	530·0	24	a_1
Captain	$11\frac{1}{2}$	1	227·0	37·0	16	...	200·0	15	40·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Charlie Ako	„	1	203·5	21·5	11	...	215·0	15	27·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sailor	„	1	175·5	35·2	20	a_1	185·0	19	20·0	a_1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tom (Tanu)	„	1, ii.	205·0	24·7	12	β_1	197·5	10	15·0	β_1	1, i.	249·0	62·6	25	a_1	280·0	22	17·5	$a_1\beta_1$	...	...	...	...	...	...	...	...
Biskak	11	1	207·0	41·6	20	...	205·0	15	45·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tom (Maboali)	„	1	207·0	14·6	7	...	210·0	13	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Harry	$10\frac{1}{2}$	1	165·5	25·5	15	...	160·0	11	25·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nanai	10	1	157·5	28·0	18	...	165·0	10	25·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
GIRLS																											
Mary	14	1	186·5	30·8	17	...	182·5	10	15·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Azau	$11\frac{1}{2}$	1	196·0	28·0	14	...	200·0	15	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dosa	„	1	219·5	28·5	13	...	210·0	17	25·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

mean[1]. In the first place, its value is very considerably influenced by even a single aberrant reaction. Secondly, while the limiting value of a shortened reaction is zero, that of a prolonged reaction is infinity. Hence the fluctuations on one side of the average are liable to be very much greater than on its other side[2]. The median, on the other hand (that value which stands midway when the data are arranged in order of magnitude), is considerably less affected by these factors. Aberrant reactions affect its value only to the same extent as do normal reactions. Consequently the median, especially when derived from a fairly large series, may be held to indicate a truer mean than the average.

Following the auditory and visual reaction-averages and medians, are two pairs of columns respectively marked *m. v.* and *m. v. q.* The columns of *mean variations* (*m. v.*) express the average deviation of the ten reaction-times from their average. The columns of *mean variations of quartiles* (*m. v. q.*) give the figures obtained by finding the median of each half of the series when arranged in order of magnitude of data, and by then taking half the sum of the difference of each of these two medians (quartiles) from the median of the entire series.

The visual choice-reactions have been arranged somewhat differently. The columns headed *median* and *of* give respectively the median of, and the total number in the series. Few series were without one, two, or even more erroneous reactions in which the individual reacted with both hands or with the wrong hand. Their number will be discussed later. The column headed *av. of* 10 gives the average of those ten consecutive right reactions in the series which agreed best with the median. As a rule, there was hardly any choice as to which group of ten should be selected. Where a choice was possible the result usually varied little, from whatever group the average was taken[3].

The columns headed *v. c.* contain a quantity which has so far received no name in psychological statistics. The *variation-coefficient*[4] expresses the ratio between the mean variation and the average. It is obtained by the formula $v.\ c. = \frac{m.\ v. \times 100}{av.}$. Its importance lies in the fact that the mean-variation depends not merely on the fluctuations of individual data from their average, but also on the actual magnitude of that average, varying directly with its value. Thus if a reagent, whose average reaction-time to an auditory stimulus is 120^{σ}, shew a mean variation of 10^{σ}, and if, reacting to a visual stimulus his average reaction-time be 180^{σ} and his mean variation be 15^{σ}, he is reacting with an equal degree of constancy in each case, although the absolute values of the mean variation are not the same.

The Arabic and Roman numerals in the columns headed *series* are easily explained by an example. For instance, 3 ii implies that the reactions in question were performed at the reagent's third sitting, and that at that sitting they had been preceded by some other kind of reaction (viz., by 3 i).

[1] I have used the word 'mean' throughout this section in the sense of the ideal average.

[2] Cf. E. Kräpelin, *Ueber d. Beeinflussung einfacher psychischer Vorgänge durch einige Arzneimittel*, Jena, 1892, S. 23.

[3] In two instances it was impossible to obtain more than nine consecutive correct reactions. The averages appear in Table XXXIV, but are preceded by the figure (9).

[4] The term has been already employed by Professor Karl Pearson in a sense only slightly different from that in which it is used here.

Interpretation of Results.

1. *Simple reactions,* (i) *Age and reaction-time.*

The following table shows that the children and older adults of Murray Island reacted more slowly than the young adults. The columns headed *Av. of med.* give the average of the figures in the 'median' columns of Table XXXIV, those headed M.V. show the mean variation of those figures from their average.

Table XXXV.[1]

Age	Auditory reactions			Visual reactions		
	No. of reagents	Av. of med.	M. V.	No. of reagents	Av. of med.	M. V.
—15	11	176·1	28·3	4	262·5	12·5
16—35	17	135·7	20·8	11	243·8	27·8
36—	19	176·2	67·8	14	260·3	64·8

This lengthening of the reaction-time in childhood and in old age has been already observed among Europeans[2]. The above table, however, shows that, while the degree of prolongation is approximately the same, the size of the mean variation within the two classes is very different, being enormously greater among the older men than among

Table XXXVI.

Age	Auditory reactions					Visual reactions				
	α-reactions	β-reactions	$\alpha+\beta$	reagents	reactions	α-reactions	β-reactions	$\alpha+\beta$	reagents	reactions
—15	1	1	2	11	143	1	2	3	4	60
16—35	9	0	9	17	270	1	8	9	11	178
36—	27	40	67	19	405	3	15	18	14	208

the children. This can only signify that the same factors are not at work, or at least are not equally active, in each case to produce the same result.

The one factor, which might be expected to contribute most to the delay of the average reaction and to the increase of its irregularity among the older men, was their greater difficulty of self-accommodation to the experiment. They were more clumsy,

[1] In this and subsequent tables only the first series of each individual's reaction-times are considered.

[2] Cf. Gabriele Buccola, *La legge del tempo nei fenomeni del pensiero*, Milano, 1883, p. 152.

less easily adaptable than the younger men or children. They had received no school-training and may (rarely) have been a trifle suspicious of our experiments. Some of them, *e.g.* Papi, persisted in reacting slowly in spite of every apparent endeavour on their part to improve. Others, *e.g.* Sisa and Dauai, gave an abundance of premature (α) and prolonged (β) reaction-times. Indeed, how far more frequent the α- and β-reactions are among the older than among the younger male islanders is well shown in Table XXXVI.

An inspection of the column of variation-coefficients in Table XXXIV. shows that in many cases the length of the older islanders' reaction-times is not due to one or two 'accidentally' delayed reactions. The variation-coefficients of Azò, Dauai, Lui, Capsize and Papi, for instance, are as low as could be expected. In other words, we may say that it was 'natural' for these older men to react slowly, *all* their reaction-times being long, often indeed passing into the region of β-reactions. There are, however, a few older men, *e.g.* Sisa and Magi, whose irregularity of reaction was extremely pronounced, owing to which the average variation-coefficient is unduly high among this section of the Murray Islanders.

The value of the average variation-coefficient of the auditory reactions among the children, younger and older adults is 13·4, 14·6 and 22·8, and of the visual reactions is 14·0, 11·3 and 15·0 respectively. (The value 14·0, however, is based on the coefficients of only four children.) Thus, the older men, both individually and as a class, react less consistently than the younger; but the difference is far better marked in the auditory than in the visual reactions. The children react quite as consistently as the younger adults in the auditory reactions, indeed giving a smaller proportion of aberrant reactions.

(ii) *Comparison with the records of English and of Sarawak reagents.*

We may now consider the Murray Island reactions along with those which I obtained by means of the same apparatus in Sarawak and still later in England. The Sarawak and Murray Island data are comparable in every respect, the individuals of each community being of all ages and the data being dealt with in the same fashion. The Englishmen's figures are less comparable. The majority of them (85 %) were either University students, a very few of whom had done two or three reactions before, or they were young laboratory assistants; the remainder were University graduates of various ages, most of whom had never tried a reaction experiment.

Comparing the young Murray Islanders with the young Englishmen and Sarawak natives, we obtain the following result:

TABLE XXXVII.

Country	Age	Auditory reactions			Visual reactions		
		No. of reagents	Av. of med.	M. V.	No. of reagents	Av. of med.	M. V.
Murray I.	16—35	17	135·7	20·8	11	243·8	27·8
England...	„	24	141·6	19·5	21	222·3	21·2
Sarawak...	„	18	120·7	10·5	9	208·0	8·7

Thus the average auditory reaction of the young Murray Island adult is not appreciably different from that of the Englishman, but his visual reaction appears to be distinctly longer. The Sarawak native reacts more quickly both to auditory and to visual stimuli than the Englishman.

The question, however, arises whether these are real differences in rapidity of reaction, or whether they are the accidental results of 'random sampling,' due, in other words, to the examination of an insufficiently large number of individuals. Between the Sarawak and the English and between the Sarawak and the Murray Island reagents, the differences are unquestionably too great to be accidental. The difference in visual reaction-time between the Murray Islanders and the Englishmen, however, is not quite three times the probable error of the differences[1]. Its significance is consequently a little doubtful, but I am strongly inclined to believe that the difference is real.

This conclusion, however, is dependent on an arbitrary selection of one of many possible ways of arriving at the mean reaction-time from the data which are under consideration. It might be thought that the results would differ, if, instead of the average of the 'median,' either the median of the 'median' columns had been chosen, or the median of the 'average of ten' columns. It might also be deemed desirable to consider separately the individuals whose series contained no α- or β-reactions, so that those who gave irregular reaction-times should no longer weigh upon the general mean. I have made such calculations for all the adult males examined in Murray Island, England and Sarawak.

TABLE XXXVIII.

	Auditory			Visual			Choice-visual	
	Murray I. (36)	England (29)	Sarawak (18)	Murray I. (25)	England (25)	Sarawak (11)	Murray I. (15)	England (18)
Median of av. of 10.....	134·2	141·0	116·7	225·0	220·5	218·5	500·5	427·1
" " " (series containing α and β omitted)...	140·5	144·2	121·5	224·0	219·7	219·0	493·0	427·1
Median of medians.....	136·2	135·0	120·0	227·5	215·0	215·0	490·0	400·0
" " " (series containing α and β omitted)...	142·5	145·0	125·0	220·0	214·2	215·0	450·0	405·0
Average of medians	156·9	140·8	120·7	253·1	218·8	215·2	501·3	411·0
" " " (series containing α and β omitted)...	146·0	145·6	126·5	235·0	211·7	217·7	466·7	417·2

These figures, it must be remembered, relate both to the older and to the younger men of the three communities. They are hence generally rather higher than those of the preceding table, but the proportion of elderly people examined in England and Sarawak

[1] Obtained from the expression $0{\cdot}6745\sqrt{\left(\frac{\overline{m.v.}^2}{n}+\frac{\overline{m.'v.'}^2}{n'}\right)}$, where $m.v.$ and $m.'v.'$ are the mean variations, n and n' the number of reagents, in the two series.

was much smaller than that in Murray Island. Moreover, a Murray Islander of thirty-five years of age or upwards is really about ten years older in appearance and vitality than an Englishman of corresponding age. Nevertheless, with a single exception, the same differences in reactions may be here recognized as before. The auditory reaction-time is shortest in Sarawak, and is approximately the same among the Murray Islanders and the English. The visual reaction-time is sensibly longer among the Murray Islanders than among the Sarawak or English reagents. The visual reaction-time of the Sarawak natives, however, is almost identical with that of the English.

2. *Choice-visual reactions.*

The mean values of these reactions, as obtained by various procedures, have been set forth in the preceding table. They are longer by about 60^{σ} among the fifteen adult Murray Islanders than among the eighteen English. Probably 15^{σ} of this time must be attributed to the same causes which produced the more delayed simple visual reaction in the case of the former. But it was clear that the Murray Islanders found relatively greater difficulty than did the English in reacting in the prescribed manner according to the colour presented. Of 345 reactions in Murray Island 45 were wrongly performed. Among the English in 329 reactions only 26 were wrongly performed; here, too, the mean variation of the reagent was less. It must be remembered, however, that most of the English reagents were a well-educated class. There can be little doubt that the Murray Islander would have compared far more favourably with the English villager in choice reaction-time. The number of α- and β-reactions in Murray Island was eleven, in England three; in Murray Island they were all α-reactions, in England ten of them were β-reactions.

The mean variation (M.V.) of the individual medians from the average of the medians is almost the same in the Murray Island and in the English adults, viz. 60·3 and 60·4 respectively. When those medians which contain α- or β-reactions are ruled out, the respective mean variations become 58·9 and 61·3.

The three Murray Island children examined gave an average choice-visual reaction which is about 30^{σ} slower than that of the adults. Their simple visual reaction-time, however, exceeds that of the adults by the same amount.

3. *Practice and Fatigue.*

About thirty successive auditory reactions were obtained at one sitting in the case of nine Murray Island adults. I attempted to find the effects of fatigue or practice by taking the average and mean variation of the first, middle and last ten reaction-times. The results, however, were complicated by premature reactions in the case of four islanders. Wasalgi gave a premature reaction in each set of ten; Kaniu, Alo and Maboali increased their number of, or began to give, premature reactions in their later records; Debe Wali, on the other hand, was able finally to react ten consecutive times without giving a premature reaction. The results of the remaining four, whose long series of reactions were without a single aberrant reaction, are given in Table XXXIX.

The improving effects of practice are well shown in the case of Wanu and Baton. Berò, on the contrary, and perhaps Jimmy Dei, seem to have been fatigued as the sitting became protracted. These differences in behaviour may be interesting when the islanders are later studied from the standpoint of individual peculiarities.

The length of the auditory reaction was not obviously affected by the sequence in which the two simple reaction-times were investigated. On the other hand, as might

TABLE XXXIX.

Name	First ten		Middle ten		Last ten	
	Average	m. v.	Average	m. v.	Average	m. v.
Jimmy Dei...	129·0	22·0	153·5	27·2	139·5	25·4
Wanu	182·0	29·2	161·0	16·4	146·1	20·2
Baton	146·0	22·4	144·5	18·6	127·0	12·4
Berò.....	121·0	7·2	125·5	9·7	129·5	11·6

be expected, a very considerable lengthening of the visual reaction-times occurred, if they had been immediately preceded by a series of choice-visual reactions. Of eleven Murray Islanders the average in eight and the mean variation in ten were greater when the visual followed choice-visual reactions, than when they preceded them or were preceded by auditory reactions[1].

4. *The Mental Attitude and Degree of Reliability of the Reagents.*

It is now generally admitted that the reaction-time of most practised individuals is longer by about 100^{σ}, when the attention is directed to the sensory stimulus, than when it is directed towards the reaction-movement; also that in the former or 'sensorial' mode of reaction premature or false reactions are rare or absent and the mean variation is large, while in the latter or 'muscular' mode of reaction the opposite is the case; and that in these respects the natural or 'central' reaction-time, where the attention is left undirected, stands intermediate between the two extreme forms. For auditory reactions the usually accepted sensorial reaction-time lies between 225^{σ} and 240^{σ}, the muscular between 120^{σ} and 130^{σ} and the central between 140^{σ} and 180^{σ}, their mean-variations lying respectively between 20^{σ} and 30^{σ}, between 8^{σ} and 12^{σ}, and between 12^{σ} and 20^{σ}. The subject having been first carefully investigated by L. Lange[2], these phenomena are sometimes collectively known as 'Lange's law.'

[1] The order of J. Allen Gilbert's investigations on the choice and simple reaction-times of children (*Studies from the Yale Psych. Lab.*, New Haven, 1894, Vol. II. pp. 40 ff.) will therefore easily account for the relatively large mean variations obtained by him in the simple reaction-experiments.

[2] *Phil. Stud.*, Leipzig, 1888, Bd. IV. S. 479 ff. But Titchener (*Experimental Psychology*, New York, 1901, Vol. I. Pt. 2, p. 214 footnote) points out that Lange had been anticipated by Orchansky, *Neurol. Cbl.*, 1887, Bd. VI. S. 265 ff.

It seemed worth while to attempt to arrange the auditory reaction-times of the Murray Islanders and of the other two communities under these three heads according to their average value. It will be noted that the mean variation of the above groups never exceeds 14% of the average. Hence in the ensuing table only those reagents will be considered whose variation-coefficient is not greater than 14. Reagents whose ten reactions include one or more α- or β-reactions are excluded. The mean-variation is given in brackets. As several of the average reaction-times fall below 120^{σ} (the accepted 'muscular' reaction), the lower limit of the central reaction has been proportionally increased to 130^{σ}; in the other direction it has been also extended to 195^{σ} for the adults and to 210^{σ} for the children.

TABLE XL.

Average reaction-times	Group	Names of reagents
104^{σ}—129^{σ}	Murray Island adults	Pasi (12·5), Charlie Boro (11·2), Mabo (4·5), Berò (7·2).
„	„ „ boys...	James (4·7).
„	English adults	Ed. (7·5), Cl. (10·4), R. (10·2).
„	Sarawak „	D. (11·4), J. (8·5), Js. (7·6), Am. (11·2), T. Tg. (10·0), Ng. (8·4).
130^{σ}—195^{σ}	Murray Island adults	Mamus (7·0), Groggy (8·7), Babelu (12·6), Dick Tui (14·5), Madsa (13·4), Deboro (12·5), Dick (Dauai) (11·4).
130^{σ}—210^{σ}	„ „ boys...	Apori (19·0), Jimmy Rice (4·7), Tom (Maboali) (14·6), Charlie Ako (21·5).
130^{σ}—195^{σ}	English adults	T. (8·5), Wn. (6·0), Ls. (15·6), Ma. (17·0), Wm. (17·5), Ry. (19·2), Jn. (10·5), Gp. (14·0), Jo. (20·8).
„	Sarawak „	T. M. (12·5), Jh. (17·9), Jl. (8·9).
196^{σ}—	Murray I., Sarawak and English adults	None.

All the above are what would be commonly regarded as 'reliable' reaction-times; in other words, all the mean-variations here are very low and the reagents gave no abnormally quick or delayed reactions. They have been obtained, be it observed, from primitive peoples, who had never before been made the subjects of experiment, and from Englishmen who with one exception had had little or no previous experience of such procedure. The averages are derived from the first ten recorded auditory reactions. Of 36 Murray Island adults examined, several of whom appeared to be quite old men, 12 (33·3̇%) appear in the above table; of 11 boys, 5 (45·4̇5̇%) appear there. Of 29 English adults examined, none of whom was really old, 12 (41%) appear. Of 24 Englishmen examined between 16 and 35 years old, 8 (33·3̇%) appear. Of 17 Murray Islanders similarly aged, 9 (53%) appear, and of 18 Sarawak adults 9 (50%). The number of consistently reacting Murray Islanders and Sarawak natives is consequently not less than that observed among the English. A study of the visual reactions leads to similar conclusions, 9 of 11 Murray Island, and 20 of 21 English young adults appearing in a corresponding table.

It will be noted that in the above table of auditory reactions there is not a single reaction-time average which approaches the accepted 'sensorial' value. The nearest of any is that of Capsize (av. = 245·5, m.v. = 31·6); but as his ten reactions include one of 360^{σ} (*i.e.* a β-reaction), his name is excluded from the table.

It would be tempting to infer that such rapid reactions, attended with such small mean-variations as those of Mabo, Berò and others, are indications that the reagents had fixed their attention on the movement to be made rather than on the sound which they expected. And perhaps such a conclusion is justifiable in the case of extremely rapid reactions. But it is quite possible that there exist wide individual deviations from 'Lange's law,' especially among the imperfectly practised. Otherwise the discrepancies obtained by Cattell[1], Flournoy[2], van Biervliet[3], Dessoir[4], Baldwin[5], Angell and Moore[6], Hill and Watanabe[7] and others, can hardly be accounted for. Probably some individuals are naturally pre-disposed to react more quickly and regularly when their attention is directed to the sensory rather than to the muscular side of the reaction, although one can hardly doubt that after adequate practice the most rapid reactions must be of the muscular type, in which, moreover, the state of the attention must be such as to lead more easily to the occurrence of premature and false reactions.

The very small number of premature, false or prolonged reactions in the visual, as compared with the auditory reactions (cf. Table XXXVI.) makes it therefore probable that the visual-reactions approximated more generally and nearly to the sensory type than was the case in the auditory reactions. The fact that the latter usually preceded the former is insufficient to explain the difference in frequency of aberrant reactions. Moreover the visual reaction-times, obtained even from Englishmen by the apparatus already described, are longer by about 40^{σ} than the muscular reaction-times usually given. It is possible that the constant 60^{σ} which I deducted for the latent period of fall of the board (see p. 206) was not sufficiently large. But I think there can be little doubt that when the sensory stimulus takes the form it had in my experiments, viz., of a distant falling board, black in colour and carrying a white card, more attention must then be given to it and less to the reaction-movement, than when, as in the shortest visual reactions, the stimulus is a mere flash of light. Indeed the reaction becomes more nearly a recognition- or discrimination-reaction than a mere simple reaction, and as a fact the values obtained by means of this visual screen (Table XXXVIII.) are closely identical with those obtained in so-called discrimination reaction-time[8], where the stimulus has to be recognized before a reaction is made.

[1] *Phil. Stud.*, Leipzig, 1893, Bd. VIII. S. 403—406.
[2] *Arch. des Sci. phys. et nat.*, Geneva, 1892, 3me Sér. Tome XXVII. pp. 575—577; *ibid.* Tome XXVIII. pp. 319—331.
[3] *Phil. Stud.*, 1894, Bd. X. S. 160 ff.
[4] *Arch. f. Anat. u. Physiol.* [*Physiol. Abth.*] 1892, S. 311.
[5] *Psychol. Rev.*, 1895, Vol. II. p. 259 ff.
[6] *Ibid.* 1896, Vol. III. p. 245 ff.
[7] *Amer. Journ. Psych.*, 1894, Vol. VI. pp. 242—246.
[8] W. Wundt, *Grundzüge d. physiolog. Psychologie*, Leipzig, 1893, Bd. II. S. 369; G. Buccola, *op. cit.* p. 274.

General Conclusions.

It appears, then, that the auditory reaction-times of the young Murray Island adult and of the young English townsman are almost identical, and that the visual and choice-visual reaction-times of the former are respectively 20^{σ} and 60^{σ} longer than those of the latter. This lengthening of the visual and choice-visual reaction-times among the Murray Islanders is probably due to similar causes. The visual reactions were really nearer recognition- than simple-reactions. Owing to the nature of the visual stimulus and the mode of its release, these reactions were clearly more difficult to execute than the simple auditory reactions. Their large average and the few aberrant values also go to indicate that in the visual reactions the attention was more firmly fixed on the expected stimulus than on the prescribed movement. In the visual, then, as in the choice-visual reactions, the attendant psychical conditions were more complex than in the auditory reactions, and in both the former reactions the Murray Islanders proved to be slower than the English. On the other hand, the young Sarawak adults reacted more quickly than the English or the Murray Islanders, the difference in rapidity between them and the English being about 20^{σ}.

The number of Murray Islanders, who gave fairly consistent reaction-times, was not appreciably different from that of the English or of the Sarawak natives. The results of every islander who was examined were capable of being satisfactorily recorded, with the exception of Canoe and Kaniu, who after prolonged trials could not be induced to react correctly in the choice-visual experiments. It is difficult to decide how far these failures were due to lack of ability or to lack of interest. My impression was that Canoe was not doing his best and that Kaniu was considerably less intelligent than most of the islanders.

The young Murray Island adults reacted more quickly than the children. They reacted not only more quickly but more regularly than the older men. Indeed, whether considered as a class or individually, the older islanders reacted far less consistently than the younger. These differences did not appear among the English, where a proportionally smaller number of men over thirty-five years of age was examined, none of whom was really old, while in Murray Island the data include those of some unquestionably aged people.

The small number of abnormally long or short reaction-times occurring among the children is worthy of notice. Their reactions were as reliable as those of the younger adults.

An interesting point, elicited by the carrying out of reaction-times in Murray Island, was the well-marked variety of temperament among the reagents. A dull steady-going islander, having plodded through a series of reactions with moderate speed but with satisfactory regularity, would be followed by a highly strung excitable individual, who

was obviously always straining his attention to the utmost and reacted perhaps quickly, but so often prematurely or erroneously that little confidence could be placed in the average of his reaction-times. Between these extreme types there was every gradation.

Other conclusions of a less general nature need not be repeated here.

Comparison with the Results of other Workers.

Before proceeding further, it is worth while considering what is implied when it is said that one people reacts more quickly than another. We must assume that in neither is practice complete. We simply mean, that in a given time one people has adapted itself more readily than another so as to perform a prescribed reaction more rapidly. It by no means follows that the reactions of the perfectly practised individuals in each community are of materially different speed. However improbable, it is conceivable that the duration of identical psychical phenomena may differ in different races. But the reactions derived from imperfectly practised primitive folk cannot provide evidence in proof or disproof of this view. The proportion of slow or irregular reagents (most of whom will react satisfactorily after adequate practice) must vary from community to community. So too will vary the general mental attitude towards the experiment, some individuals naturally turning their attention always in the direction of the stimulus or of the movement[1], some attending now to one, now to the other, others reacting almost automatically, only dimly conscious of the nexus between sensation and muscular action. In this sense, reaction-times may be said to vary inter-racially.

The earliest suggestion with which I have met, that the reaction-time is dependent on the race or country of the reagent, was made in 1879 by A. Herzen[2]. His unpublished experiments led him to believe that Italians react more slowly than Germans. More recently Th. Flournoy[3] has considered the type of reaction to depend on "anthropological or ethnographical characters." He holds 'Lange's law' to be proven for most Germans and Russians, and to be reversed in the case of the South European nations (French, Servians, Roumanians and Greeks).

The reaction-times of some Japanese conjurors were investigated by Herzen more than twenty years ago. I have been unable to find a record of his experiments. He concluded[4] that the Japanese react more slowly than Europeans.

In 1895 a paper, entitled "Reaction-time with reference to Race," was published by R. Meade Bache[5], in which, after giving the results of visual, auditory and tactual reaction-investigations made by L. Witmer upon a few American Indians, Negroes and Caucasians, he concludes that the reaction-time is shortest in the lowest and is longest

[1] Alechsieff, for instance (*Phil. Stud.*, 1900, Bd. xvi. S. 18), states that the sensorial reaction is impossible to some, especially to those who are predisposed to the muscular reaction. Hill and Watanabe (*loc. cit.*) observe that "some never reach the quickness of the muscular reaction, some, while reacting constantly do not conform to the Lange type."

[2] *Archiv. per Antropol. e la Etnolog.*, 1879, Vol. ix. p. 91, footnote.

[3] *Observations sur quelques types de réaction simple*, Geneva, 1896. Ref. in *Ztsch. f. Psych.*, 1897, Bd. xiii. S. 359.

[4] Cf. *Biolog. Cbl.*, 1881–2, Bd. i. S. 730.

[5] *Psychol. Rev.*, 1895, Vol. ii. p. 475. A preliminary note appeared in *Proc. Amer. Philosoph. Soc.*, 1895, Vol. xxxiv. p. 337.

in the most advanced races. This opinion is based on the examination of 12 Caucasians, 11 Indians, and 11 Africans who had "a larger intermixture of white blood in their veins than have the Indians on the corresponding list." The average of ten observations and their mean variation are given for each individual. The author, however, does not specify that the ten reaction-times taken were consecutive. It appears to me likely that the ten quickest or most regular of many reactions were chosen, seeing that the variation-coefficients, if calculated in the case of three individuals, fall to 2·6, 2·7, 2·8,—values which are very considerably lower than those obtained by me and others from untrained and even from trained reagents. Among the Indians, moreover, is included a youth whose average auditory reaction-time is only 70^{σ}. Although his mean-variation is said to be only 6·2, one cannot help wondering what limits, if any, were set from which premature and false reactions were eliminated. Finally, the inequality in age of the individuals within each series makes comparison between the three races very difficult. The Caucasians include four boys below the age of 16 of whom two react more slowly than any of the rest. The Africans include none below the age of 16. If the boys be neglected, the average reaction-times of the Caucasians are almost equal to those of the Africans. The Indians, however, remain with reaction-times by some 15^{σ} quicker than those of the other two races.

The rapid reactions of the Sarawak natives, as compared with those of the English, have been noticed in these pages already. It is interesting to find that the American Indians, who are near akin, appear to be similarly characterized.

The same, too, has been noted quite recently of the Javanese 'Malays,' who are yet more closely allied to the people of Sarawak. G. Grijns[1] has recently investigated the reaction to electric cutaneous stimuli among some nineteen Javanese students and many Europeans. He concludes that the native reaction-time is decidedly quicker than that of Europeans who have lived for some time in Java, and is (though less markedly) quicker than Europeans who live in Europe.

Lastly, there are a few tactual reaction-times, published in 1901 by L. Lapicque[2], which were made upon eighteen Andamanese, and seven convalescent Hindu criminals, and were compared with those of twenty-eight Europeans. Owing, apparently, to the individual variations among the latter, according as he worked with British officials of the Andaman Islands, with Parisian labourers, students or paupers, the writer concludes that the problem which he set himself, viz., "the determination of the influence of race upon reaction-time, is...illusory." Like so many others, he gives a very imperfect account of his method, but, as far as his few observations go, the reaction-times of the Andamanese, and especially of the Hindus, are distinctly longer than the seventeen European officials, students and labourers, and are slightly longer than the eleven paupers.

In every case one would have preferred a greater body of evidence, and an assurance that the differences are more than chance differences due to insufficient experiments; but it is interesting to note that, while the people of Java, Borneo and North America react more quickly, the African (cross-bred), the Hindu (criminal), the Andamanese and the Papuan appear to react with the same speed as, or more slowly than, the Caucasian.

[1] *Arch. f. Anat. u. Physiol.* [*Physiol. Abth.*], 1902, S. 1—10.

[2] *C. R. de l'Acad. des Sciences*, 1901, Tome CXXXII. pp. 1509—1511.

The early experiments on the Japanese by Herzen, which, if ever published in detail, I have been unable to find, are the only observations I know of which as yet negative this conclusion; we should expect them to fall into the first instead of into the second of the above-mentioned groups.

Such racial differences in reaction-times, if actually established by further research, may turn out to be merely the expression of racial differences in temperament. For it is easily conceivable that a highly strung, nervous people cannot develop the disposition, or assume the attitude, that is favourable to the most rapid and regular reactions with such readiness as can a relatively unemotional people. Moreover, it is at least suggestive that what little evidence we have tends to show that the more excitable Italian and Papuan react less rapidly than the more phlegmatic Teuton and Malay. If, however, we bear in mind how wide are the elementary psychical differences, which in all likelihood underlie seemingly similar temperaments, the unwisdom of venturing on such a general statement is at once obvious.